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THOREAU AND HIS RAINBOW

By C. A. CHANT

FOR many years I have enjoyed the writings of Henry David Thoreau, and have been interested in criticisms which have been launched against him from time to time. In the July *Atlantic* is an article by the well-known American writer Charles D. Stewart, entitled "A Word for Thoreau", in which he attempts to defend this author from his detractors.

He begins by quoting the familiar statement made by Thoreau in the description of his visit to Baker Farm which forms the tenth chapter in "Walden", as follows:

> Once it chanced that I stood in the very abutment of a rainbow's arch, which filled the lower stratum of the atmosphere, tinging the grass and the leaves around, and dazzling me as if I looked through coloured crystal. It was a lake of rainbow light, in which, for a short while, I lived like a dolphin.

Perhaps the severest critic of Thoreau's observations of nature was John Burroughs, who, regarding this picturesque description, has the following remark to make:

> Is it possible, then, to reach the end of the rainbow? Why did he not dig for the pot of gold that is buried there? How he could be aware that he was standing at the foot of one leg of the glowing arch is to me a mystery. When I see a rainbow it is always immediately in front of me, I am standing exactly between the highest point of the arch and the sun, and the laws of optics ordain that it can be seen in no other way. You can never see a rainbow at an angle. It is always facing you squarely. Hence no two persons see exactly the same bow, because no two persons can occupy the same place at the same time. The bow you see is directed to you alone. Move to the right or left and it moves as fast as you do. You cannot flank it or reach its end. It is about the

most subtle and significant phenomenon that everyday Nature presents to us. Unapproachable as a spirit, like a visitor from another world, yet the creation of the familiar sun and rain.

Mr. Stewart proceeds to describe observations which he made in the summer of 1934. When on the prow of the *Maid of the Mist* at the foot of Niagara Falls he saw a bow which "was quite complete, with myself or the prow for the centre of its half circle". After landing from the vessel he saw a bow which was quite different. "This one had its foot directly in front of me and so near that I could have tossed a pebble into it or reached it with a short fish pole. From this point in front of me it arched to the left: it was entirely to the left of me." Later, when experimenting with a lawn sprinkler, he said:

> We turned it on late in the afternoon of a sunny day and it made a beautiful bow, or rather the foot of a rainbow whose curve swung off to the left. Then I walked around it slowly and the curve suddenly went up in the opposite direction. This was a right-hand rainbow. Evidently there was no preference in nature. If the sun shone over my left shoulder there was a bow curving to the right, and if the sun came over my right shoulder there was a bow extending off to the left.

Now the conditions requisite for the formation of the rainbow are perfectly definite. It can be produced easily in the laboratory and the theory of its production, based on the laws of optics, have been verified by actual measurement. There must be a source of light behind the observer and drops of transparent material before him. Usually, of course, the source is the sun (although the moon will serve) and the drops are of a shower of rain. The primary bow is a portion of a circle, the centre of which is on the line drawn from the sun and passing through the observer's eye, and its angular radius is about 42 degrees. Ordinarily the raindrops are at a considerable distance and the bow appears far away up in the sky; but when they are nearer the bow may seem close at hand and quite small.

The most striking bow which I have observed was seen from a stairway at the foot of the American fall at Niagara on a bright summer day at about 11 a.m. Looking downwards a brilliantly coloured complete circle could be seen, apparently suspended in the air about thirty feet away, and the line from the sun through my

eyes passed through its centre. From the way the bow is produced it follows that two persons do not see the same bow.

But let us consider the question a little further. Did Thoreau really intend to state that he actually had been within a rainbow which he himself could recognize as such? I do not believe he did. Undoubtedly he knew that a rainbow was due to the sun and drops of water, although he probably did not understand just how the sun's rays were refracted and reflected by the little spheres of water. On the occasion referred to by him there were present a bright sun and a mist consisting of fine water drops. From them there resulted an iridescence which enveloped him and which he felt must be like that in the end of a rainbow—which would be seen as such by some one in the proper position. His reference to the dolphin indeed gives a touch of fancy and mysticism to the picture, which is not to be interpreted with absolute literalness. In reading Thoreau one should try to enter into the spirit in which he lived and wrote.

However, I may refer to an optical phenomenon described by Thoreau to which he offers an explanation which is certainly invalid. In the chapters in "Walden" entitled "House-warming" and "Spring" he speaks of bubbles seen within the ice of Walden Pond and he states that the lower side of the ice directly beneath the bubble was concave; in other words, that the ice there was thinner. He suggests that the bubble, being lens-shaped, acted as a burning glass and melted the ice beneath it. As a matter of fact, a lens-shaped air bubble in an ice medium diverges the light so that its action is the reverse of a burning glass. I have not verified the statement that the ice is thinner below a bubble, but if such is the case it is not due to the cause assigned.

MAKING THIN MIRRORS FOR REFLECTING TELESCOPES

By Harold C. King

(A Paper read before the Astronomers of Calgary)

SOME dicta are proved to be wrong by their supposed explanations. If there is anything illogical in the explanation, there is probably something wrong with the whole proposition.

Consider for example the dictum that the mirror of a reflecting telescope must be made of glass which has a thickness of at least one eighth of its diameter, and is said to be better still if it is as thick as one sixth of its diameter. According to this an eight inch mirror should be at least one inch thick, and would be better still if it were about one and a third inches thick.

The reason given for this thickness, in the book, "Amateur Telescope Making" published by the Scientific American Publishing Co., is that if the mirror is made of glass having a less thickness in proportion to diameter than one eighth, it will not keep its figure. That is, it will warp, the reason for the warping being that "it will bend with its own weight."

Even supposing it to be true that thin mirrors are found to warp, the explanation that this is caused by its own weight, is illogical on the face of it. It should be obvious that if the mirror is thin there is therefore less weight to warp it.

On the strength of this reasoning I determined to make a thin mirror. I had a piece of glass on hand a half inch thick and nine and a half inches in diameter, and I have made a mirror out of it. This you will observe is a ratio of nineteen to one as between diameter and thickness.

When I had got the required curve and polish, also the correct figure, I discovered there were numerous grit marks in it. But as it was only an experiment to see if the curve would hold I did not bother about the grit marks. But I silvered it and put it in the telescope. That was six months ago, and the instrument has been in constant use since without the slightest change in its figure. Its star images are excellent, and the detail revealed on the moon or planets leaves nothing to be desired.

I have explained that I did not believe that a thin mirror warped because of its own weight. But I did believe that thin mirrors had been found to lose their figures. It was the explanation that I doubted, not the fact.

I doubted that the weight, within reasonable limits, had anything to do with it. Then what did make thin mirrors warp? If it was not the weight that caused it, it must be caused by something else. So I concluded that a thin mirror loses its figure after completion because, being thin, it was warped in the grinding and polishing process, and when it was allowed to rest afterwards the strained glass gradually resumed its normal condition. If you polish to a perfect figure when the glass is in a warped condition, it is obvious that you will not have a perfect figure after the warping has passed away.

Those of you who have made a mirror, or read about the process, will know that according to the book mentioned it is customary to affix a wooden handle to the middle of the disc to hold it while grinding and polishing. Such a handle makes a sort of support for the middle of the disc, but leaves the outer circumference to spring under the pressure of the polishing process. It is reasonable to suppose that the unsupported portion of the disc will become warped, but that when the mirror is finished, and the glass allowed to rest for some time, it will gradually become unwarped. Hence the loss of correctness in the curve.

So I decided to support the disc over its entire area. To accomplish this I stuck a ribbon of paper round the edge of the disc, with about an inch of the ribbon extending beyond the edge, thus making a shallow dish about an inch deep. I then poured melted pitch into the dish thus made, until it was full. Before the pitch had set I placed on top of it a disc of hard wood the same size as the mirror and about an inch thick.

When the whole thing was cold the result was that my disc of glass was backed with a cushion of pitch an inch thick plus a piece of wood an inch thick, the back of the mirror being supported over its entire area.

I then started to grind, smooth, and polish. During the process I occasionally immersed the whole thing in water which I gradually

heated until the pitch was slightly soft. I did this so that in the event that any warping was occurring the softening of the pitch, and the effect of the warming of the glass, would restore the glass to its normal condition. I continued the polishing, with occasional fixings to the lap—I used a pitch lap—until by the Foucault test the curve was satisfactory.

The removal of the mirror from its pitch backing was easy. I just put it in water, gradually heated it, and presently was able to remove the mirror. I scraped as much of the pitch as possible off the back while it was still warm, and removed the remainder by means of turpentine. When it was cold I tested the mirror, and found it to be unaltered. I silvered it and put it in the telescope. That was six months ago, and its figure is as good today as then. Some of you gentlemen have yourselves used the instrument and can testify as to its satisfactory performance.

Before closing this paper I had better say a word about the mounting of the mirror. It just sits in a shallow tin can having a lid. Between the edges of the can and the edges of the mirror I gently inserted pieces of cork, touching, but not pressing upon the edges of the mirror. A ring of cardboard, held in position by a ring of stout wire, sits lightly on the edges of the mirror, preventing it from accidentally falling out of its tin can cell, but not pressing upon it. In fact the mirror has a slight shake, so it is not under pressure in any way. I have been getting first class results with the telescope ever since.

In conclusion: it is important to remark that temperature troubles simply do not exist. The temperature can change as much as it likes, but the mirror, being thin, adapts itself to temperature changes with great facility. On some occasions I have brought the telescope out of my garage, where I store it, at a time when there has been a fire in the garage, and the temperature of the garage has been about seventy degrees, while the temperature outside was zero. But five minutes after being set up outside the effect of the violent change in temperature had ceased and the instrument was fit to use.

This experiment in thin mirrors has been successful, but I would be glad if other mirror makers would try the same experiment. I submit my results for what they may be worth.

THE NEWER TELESCOPES*

By Henry Norris Russell

EVERYONE who has used a camera knows that a good lens should meet severe conditions. It must bring the rays to a *sharp focus*, not only at the centre of the image but over a *wide field* of view. It must bring light of all colours to the same focus—that is, it must be *achromatic*; and it is very desirable, though not necessary for all purposes, that it should give a bright image, permitting short exposure—it must be *fast*.

We all know, too, that to get an achromatic image even approximately, our objective must be made of two component lenses of different kinds of glass. To get a sharp focus over a wide field there must be three or four components in the objective, instead of two. Finally, a fast lens must be of large diameter compared with its focal length.

To meet all the conditions, which have here been merely outlined, demands the highest skill of the designer and the optician, so that good lenses are necessarily costly, even in the small sizes used in ordinary cameras. For the larger apertures used in astronomical work there is added the great difficulty of casting perfectly flawless disks of glass.

Some of these difficulties may be altogether removed and others greatly diminished by using mirrors instead of lenses. A reflecting telescope is perfectly achromatic, and the ratio of its aperture to its focal length can be made much larger than is practicable for a two-component lens. Moreover, by figuring the surface to an exact paraboloid of revolution, all the light of a star may be brought to geometrically exact focus—barring the inevitable effects of the diffraction of light waves, which are alike in all instruments of a given aperture.

Despite these important advantages, the reflector has one very grave disadvantage. Its field of good definition is severely limited.

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*From *Scientific American*, June, 1935.

The condition that all the parallel rays of a beam of starlight shall be brought by reflection to a sharp focus fixes the *form* of the mirror surface completely. It may be obtained by rotating a parabola about its axis. The only freedom left the designer is to determine the size of this parabola—that is, the focal length of his mirror—and of course to decide how large a portion of the infinite geometrical surface shall be arbitrarily brought into being upon his glass disk. But this paraboloidal surface will perform ideally well only when the stars' rays come to it along the direction of its own axis. If they are inclined to this at even a small angle, the rays reflected from different portions of the mirror will not converge to the same point. Those from the outer zone do not come to a focus at the same distance from the mirror as those from a zone near the middle of the mirror and their best approximation to a focus is displaced laterally away from the centre of the field, so that the image becomes a roughly triangular mass like a half-opened umbrella or a tiny comet with a wide, bright tail.

This "aberration" of the image is called coma. It is always present, theoretically, except at the very centre of the field. Its amount increases proportionally to the distance of the star from the centre, and also to the square of the ratio of the diameter of the mirror to its focal length. The brightness of the image of any extended object, such as a nebula, is proportional to this last quantity. It is therefore impossible, with a single reflecting surface, to secure a bright image and a wide field at the same time. The star images go bad quite near the centre.

With an aperture one-fifth of the focal length, as in the 100-inch telescope at Mount Wilson, the deterioration of the images becomes perceptible to a trained observer at 3′.6 from the centre, so that the field of really satisfactory definition is only one-eighth of a degree in diameter. The 200-inch telescope will have to be made shorter in proportion to its diameter, to avoid enormously increased cost, and Dr. Ross calculates that the images will be really sharp in a portion of the plate less than one inch in diameter. It may be repeated that this property of the simple reflecting telescope arises from simple, though not quite elementary, considerations of geometry. It is incurable—unless we decide to make our telescopes more complicated

in design. Then there are many ways of escape. By using two mirrors which divide the image-forming work between them, additional degrees of freedom become available and coma may be eliminated over a wide field.

The first such scheme worked out in detail was by Schwartzschild, the most distinguished German astronomer of all times, in 1905. It employs a main mirror of small concavity, with a second more concave and of half the diameter placed in front of it (Figure 1). This gives a flat field, with good images over a region two degrees or more in diameter, and has great light-power, since the effective focal length, as determined by the scale of the image, is three times the

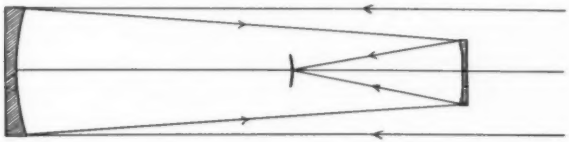

FIG. 1.—Illustrating Sschwartzschild reflector.

diameter of the large mirror. But the tube from one mirror to the other is 25 percent longer than for an ordinary reflector. The loss of one-quarter of the light by interposition of the second mirror is not very serious.

A reflector of this type is under construction for the University of Indiana. A second type, in which the small mirror is convex, 30 percent the size of the big one, and much nearer to it, was designed by the French astronomer Chrétien. A 40-inch telescope of this design has been constructed for the United States Naval Observatory by Mr. G. W. Ritchey.

It is also possible greatly to increase the available field of a parabolic mirror by interposing a specially constructed lens not far in front of the focal plane. The very complicated theory necessary for the design of such "correctors" has been developed by Dr. F. E Ross, and lenses of this sort have been adapted to the 60-inch and

100-inch reflectors at Mount Wilson with great success, and will be provided for the 80-inch in Texas and for the 200-inch in California.

These devices, while of high value for use with large telescopes, do not permit the construction of mirrors with as favourable a speed-ratio as can be attained by the best lenses. A ratio of f/3.3 (that is, a focal length 3.3 times the aperture) is about the best that has been attained, while specially designed lenses have gone almost to f/1.0. Such image-forming systems of short focus and great speed are especially important for astronomical spectographs. The collimation of such an instrument—a small reversed telescope which receives the diverging beam of light after its passage through the slit and turns it into a parallel beam so that it may pass through the prisms without distortion—has perforce to be designed with the same ratio of aperture to focal length as the telescope which feeds it. (Even with the reflectors this is small, for the spectographs are used with a secondary concave mirror which lengthens the focus.) When there is plenty of light a long camera behind the prisms gives a large image full of rich detail. But, for faint objects and especially for extended surfaces such as nebulae, a short camera is necessary. This increases the intensity of the image by diminishing both its length and its breadth. Moreover, the spectral lines of the plate, being reduced images of the slit, are very narrow, and the slit may be widened, admitting more light without fuzzing up the negative perceptibly.

It was by inventing this short camera that V. M. Slipher at the Lowell Observatory succeeded, with a telescope of moderate size, in obtaining the first good, detailed spectrograms of the spiral nebulae, and so began one of the most striking advances of modern astronomy.

Now short focus lenses up to an inch or so in aperture can be perfectly well made, though it is skilled work. But a lens six inches in aperture and of similar shape would be so thick that much light would be lost in passing through the glass, and would be extremely costly to make.

A most ingenious solution of the problem has recently been made by Dr. B. Schmidt of Bergedorf, in Germany. The "Schmidt camera" uses a mirror instead of a lens, and returns to a very old practice by making its mirror spherical. Now every telescope maker—amateur

or professional—knows that a spherical mirror is much easier to make than a paraboloid—indeed most mirrors are originally made spherical and then parabolized by gradually polishing away the excess material. But a spherical mirror, as all workers know, gives a most unsatisfactory image. The rays reflected near the edge cross nearer to the mirror than those which come nearer the centre, and no sharp image can be secured, as is shown in Figure 2 (where the effect has purposely been exaggerated by taking the diameter more than twice the focal length).

This effect may be eliminated by changing the mirror to a paraboloid, but only at the price of introducing coma and narrowing the

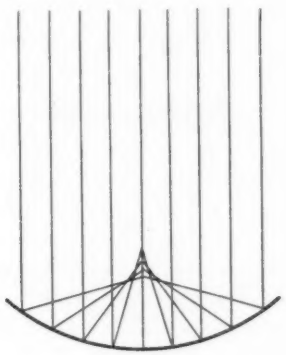

Fig. 2

FIG. 2.—Illustrating the action of a spherical mirror and FIG. 3, how it is corrected in the Schmidt camera.

field of good definition. In place of this Schmidt introduces a "correcting plate"—really a very thin, concave lens in front of the mirror. Its action is obvious from Figure 3. The rays near the centre are very little deviated, while those passing near the edge are bent outward, and these strike the mirror at such angles that all are reflected exactly toward the same focus.

Even for the enormously exaggerated case shown in the picture, the plate is thin in comparison with its diameter, and its surface is

considerably curved only near the edges. In practical application the curvature of the surface is so small that it is only perceptible by optical testing. A plate 12 inches in diameter, for example, will have surfaces which are never more than a thousandth of an inch removed from planes. After it has been carefully figured to its proper shape one would take it for an ordinary piece of parallel-faced glass—unless, indeed, one applied the severe test of looking through it at a very oblique angle.

With such a correcting plate the central image of a star becomes substantially as good as with a parabolic mirror. (Theoretically there

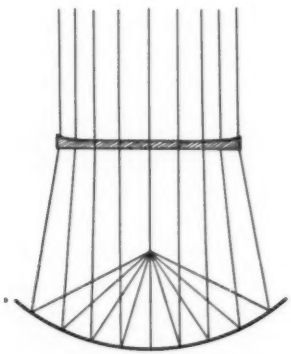

Fig. 3

is a slight departure from achromatism, due to the dispersion of the glass, but this is usually negligible in practice.) But the great advantage of this device is that the images of objects several degrees from the axis are almost as good as those at the centre of the field. The spherical mirror itself produces no coma—only spherical aberration, and this to exactly the same amount no matter whether the rays fall on it from one direction or from another, for all parts of a sphere are alike. Inclined rays differ from axial rays only in passing through the plate at an angle. Now the whole effect of the plate is to introduce a distortion into the beam of rays, just sufficient, when they traverse it squarely, to undo the spherical aberration of the

mirror. Rays traversing the plate at a moderately oblique angle will suffer very slightly greater deviations, the effect being a minimum for perpendicular incidence. As the deviations are small anyway, this change will be almost imperceptible, and the effect will be almost perfectly adapted to neutralize the aberrations of the mirror. In consequence, the images are good over a remarkably wide area. Mr. Schmidt has obtained photographs having a workable field 12 degrees in diameter.

A series of Schmidt cameras is under construction for the large spectograph at Mount Wilson. By careful calculation of the curve of the correcting plate, an extraordinarily high speed-ratio can be secured. A camera with ratio f/1 is already in successful use, and one of f/0.57 is under construction, with an aperture 1¾ times the focal length! This should be of extreme value in observing faint stars.

At present this new device is likely to be of more service to the professional than to the amateur. The cross-section of the correcting plate is a curve of the fourth order, which must be calculated by the maker, and the figuring of the surface demands a rather unusual type of work. Moreover, the final focal image is not flat, but upon a spherical surface of radius equal to the focal length, so that special curved films would be required to cover a wide field. The very novelty of these problems, however, may be a challenge to the student who has already mastered the simpler technique of the ordinary mirror.

IN THE GRIP OF THE BIG TELESCOPE AGE*

TO the great majority of people the terms "astronomy" and "big telescope" are probably synonymous terms. The stories of how large moulds of glass weighing many tons are given so many months to cool from the molten state; of how the surface is worked to within so many millionths of an inch to obtain the correct figure; of the great building housing the completed instrument; and lastly, but most important of all, the wondrous sights obtained through the telescope are apt to cause general readers to overlook the value of other factors in the production of useful astronomical observations. It is the great telescope alone—the magic tube enabling one to see beautiful and undreamt of pictures in the heavens—which has captured the popular imagination.

Let it not be forgotten that many factors other than the telescope itself enter into the successful use of any instrument. The mechanical parts need all possible care. For successful photographic work it is necessary for a telescope to be not only rigidly and truly mounted, but also that a good driving clock must make the best use of such a mounting. No one will question the value of a surveyor, and the general accuracy of his work, and if the "astronomically interested" people will look at a theodolite they will gain the spirit of this article. Although optically a beautiful production, the little telescope of a theodolite must seem a miserable affair to those who have a mental picture of a giant telescope. The surveyor knows that the accuracy of his instrument depends not only on the telescope, but also on the mechanical accuracy of the moving parts and of the divisions of the circles.

Also no matter how good a telescope may be, it is necessary that the human element be taken into account. "It is the man behind the gun that counts", wrote one famous astronomer. Four hundred years ago, before telescopes were known, this principle received recognition

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*From *Southern Stars*, the journal of the New Zealand Astronomical Society, February 1935. (I. L. Thomsen, *Editor*)

by the youthful Tycho Brahe. Ball tells us that "Tycho used to conduct his observations on those thoroughly sound principles which lie at the foundation of all modern astronomy . . . this principle, employed by the boy with his cross-staff in 1564, is employed at the present day by the Astronomer Royal at Greenwich with the most superb instruments that the skill of modern opticians has been able to construct".

These few thoughts lead to the important realization that all astronomical problems cannot be solved by using a 200-inch telescope any more than they can by a 3-inch telescope. Each has its own field of usefulness, and the amount of usefulness depends on the ingenuity, carefulness and patience of the user. After comparing the results to be obtained with the 40-inch Yerkes refractor and a 4-inch refractor, Hale in 1907 said, in a lecture before the Royal Astronomical Society, "I have shown these illustrations for the purpose of emphasizing what is perfectly well known to all of you, that each instrument has its particular fields of work, in which it can accomplish, or permit to be accomplished, various investigations which are not within the reach of other kinds of telescopes". Writing in 1922 Dr. Paul Merrill stated, "The idea that it is hopeless or unwise to attempt any problem of investigational astronomy with a small or a moderate sized telescope is certainly ill founded. Large instruments have not and will not destroy extensive fields of usefulness".

Some important steps in the advancement of astronomy have been made by users of small telescopes. To give a complete list would take more space than can be afforded. In the earliest times we have Galileo and Fabricius demonstrating that sunspots are objects on the sun, and that the sun rotates. Scheiner determined the period of rotation of the sun and the position of the solar equator. Schwabe in 1851 announced the discovery of the 11-year cycle of sunspot activity, and, following up this work with a 3-inch telescope, Wolf established the system of sunspot numbers which is still used. The brilliant work of Burnham on double stars with a 6-inch telescope is a classic in showing how small telescopes pave the way for larger instruments. A good case could be made out for variable stars, in fact a great amount of work at the present day is done with instruments little more than three inches in aperture. If we wish to delve into

the higher problems of cosmography we have the recent example of Shapley demonstrating the fact that the Andromeda nebula is many times larger than was formerly supposed, from a photograph taken with a lens only one inch in aperture. In the field of comets the scope is unlimited. Not so many years ago we had the case of a Japanese labourer, Nagata, discovering an important comet while he was interesting himself by watching Neptune with a 3-inch telescope. In 1932 Geddes in New Zealand, using a 5-inch telescope, discovered an important comet which is still being followed. Readers may like to make a hobby out of preparing lists of all the important discoveries that have been made with small telescopes. They will certainly be surprised at even the future possibilities. From recent work by amateurs in England there appears to be still plenty of work to do on the moon. R. A. Proctor wrote, "I may add that in the year 1869 I carefully examined every object included in Webb's map, with a telescope 2¼ inches in aperture, using low powers, and satisfied myself that the map fulfils in every respect the object aimed at by its designer. And here, in passing I may remark that I cannot indicate a more pleasing occupation for the possessor of a telescope of that size (or any larger up to four inches) than to go over the moon's disc, examining each object seriatim, and carefully comparing what is seen with the appearance shown in the photographs".

At the conclusion of the lecture already referred to, Hale said, "I hope I have shown that it is possible not merely to do work of an inferior quality, but to do work of the first quality with small or inexpensive instruments; work that cannot be duplicated or will not be duplicated with large instruments; in other words, that there is a splendid field for any man who wishes to accomplish results, wherever he may be situated, and however simple his means of research may be. We need the ideas of men from all parts of the world; we need the contributions they can make; and we need them even more than we need larger instrumental means than we now possess."

METEOR NEWS

Observations relating to meteors and meteorites are cordially invited.

Meteor Spectra—List II

It was proposed last year to publish annually in this department a list of the recent photographs of meteor spectra. List I, in the Journal for July-August, 1934, included the meteor spectra photographed up to the end of 1933. List II, found below, contains all spectra which, to the writer's knowledge, have been photographed in 1934. Should any have been omitted, the writer would appreciate being informed of the fact. The spectra have been numbered in chronological order as in the previous tabulation. These numbers provide a convenient means of referring to any particular spectrum.

Photographic Meteor Spectra—List II

Spectrum	*Date*	*Time*	*Place*	*Identification*
XXX	1934, Aug. 4	22.58 C.S.T.	Ft. Worth, Texas	δ Aquarid?
XXXIa	1934, Aug. 12	1.22 E.S.T.	Richmond Hill, Ont.	Perseid
XXXIb	" "	"	Richmond Hill, Ont.	"
XXXII	1934, Aug. 11	23.30 P.S.T.	Table Mt., Calif.	———
XXXIII	1934, Aug. 12	3.08 C.S.T.	Ft. Worth, Texas	Perseid
XXXIV	1934, Aug. 12	3.34 C.S.T.	Ft. Worth, Texas	Perseid
XXXV	1934, Aug. 13	0.20 E.E.T.	Moscow, U.S.S.R.	Perseid
XXXVI	1934, Aug. 13	3.18 E.S.T.	Richmond Hill, Ont.	Perseid
XXXVII	1934, Aug. 13	3.41 E.S.T.	Richmond Hill, Ont.	Perseid
XXXVIII	1934, Dec. 13		North Toronto, Ont.	Geminid

Especial mention should be made of the Texas Observers at Ft. Worth who, during the last three years, have been consistently adding to the number of meteor spectra in existence. This result has only been accomplished by systematic photographic programmes, painstakingly carried out during the year's best meteor showers. The Texas Observers are responsible for three spectra in the above list, Nos. XXX, XXXIII, and XXXIV. They have photographed six spectra out of the present total of thirty-eight, certainly a fine record for one group of amateurs and a good example of what the serious amateur can do to assist in the advance of astronomical knowledge.

Spectrum XXXII was photographed by Professor W. T. Whitney of Pomona College, Calif. It was taken with a new type of rotating spectrograph, designed to follow the meteor in flight. Spectrum XXXV was taken by Mr. K. P. Stanjukowitsch, secretary of the Meteor Section of the Moscow Astro-Geodetic Society. It was obtained during an extensive campaign for observation of the Perseids. Direct photographs of the same meteor were also obtained. The remaining spectra were secured by the writer. No. XXXI (taken with two cameras), and Nos. XXXVI and XXXVII were photographed during the Perseid observations at the David Dunlap Observatory of the University of Toronto. Spectrum XXXVIII was obtained during observations of the Geminids from a station in the north of Toronto.

It is gratifying to see the wide geographical distribution of the observing stations in the above table, which indicates the international interest in meteor spectrophotography. In addition to this, there are a number of enthusiasts who have been observing with meteor spectrographs but who failed to secure spectra in 1934.

A study of meteor spectra I to IX will be found in the Harvard Annals, vol. 82, no. 6, 1932. The writer has just published an analysis of spectra X to XXIV in Harvard Annals, vol. 82, no. 7, 1935. Analysis of most of the remaining spectra is now under way at the Dunlap Observatory.

P.M.M.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Delay in this Number

It was hoped to give in this issue a full account of the official opening of the David Dunlap Observatory on May 31, but a lack of some of the material has caused it to be postponed until the next number.

Misunderstanding in Mr. Andrew Thomson's Article

In the article by Mr. Andrew Thomson in the April Journal on "Variability in Canadian Winters" a sentence at the foot of p. 130 gave rise to some misunderstanding. It reads:

> In the winter season, January is the coldest month in Canada, except in old Ontario, Nova Scotia and Prince Edward Island, where the coldest month is February. The reason for the long delay of the coldest weather in both regions in spite of the sun's increase in declination after December 21st is obscure. At Toronto over a period of 58 years, 1840-98, the coldest day in the year was found to be February 5th.

Mr. Thomson was referring to the lag of the coldest weather in Ontario and the Maritime provinces behind the coldest weather in other parts of Canada.

The Atmosphere of the Planet Mercury

The question of the existence of an atmosphere on the planet Mercury arouses continued interest. Observational astronomers believe that they have evidence of an atmosphere, while theoretical astronomers assert that the well-established laws of physics lead to the view that the little planet is not able to retain a gaseous envelope about it. The problem is discussed by C. O. Bartrum in a recent issue of the *Journal* of the British Astronomical Association and a summary of his conclusions is given by *Science Service*:

> When, at rare intervals, Mercury passes directly between the sun and earth in transit, there is an instant when the planet is half in front of, and half off, the solar disk. Then, the presence of an atmosphere may show itself by a ring of light which appears completely around the planet. The air on the edge of Mercury away from the sun would bend some of the light around

it, just as the earth's atmosphere bends the sunlight so that we really continue to see the sun for a short time after it has set.

With the ordinary transit, such as last occurred in 1924, there is such a brief period, at the beginning and end, when Mercury is thus at the edge of the sun, that there is little time to make any detailed observations. The transit of 1937 will not be visible from England or northern Europe, for from these parts of the earth the planet will just miss coming in front of the sun. But in south-eastern Europe and in Africa it will be seen, and there the planet will just skim along the sun's edge, hanging there for about forty minutes. Such a transit occurs but once in nearly a thousand years, and thus it should provide an excellent opportunity of studying Mercury at leisure to see whether there is the arc of sunlight around the portion not projected upon the sun's disk. "The presence or absence of such an arc would go a long way to settle the conflict between the planetary observers and the theoretical astronomers," according to the author of the note.

The Star Fomalhaut

We are told that among the Persians the four stars—Fomalhaut, Regulus, Aldebaran, and Antares were designated Royal; they were the four Guardians of Heaven. Differing as they do by about six hours in Right Ascension, they were used in early days to mark the equinoctial and solstitial colures, i.e., the four great circles forming the quarters of the heavens and were regarded as sentinels watching over the other stars.

As the name Fomalhaut is Arabic and not French, its pronunciation is not Fomal-o, but Fomal-hawt. It is now known as Alpha Piscis Australis, but it has had names innumerable chiefly connected with fish or fishing or things aquatic thus, from its great brightness Piscis Magnus; from its loneliness, Piscis Solitarius. Later on Longfellow, in his translation of Dante's Divine Comedy, called it, I believe, the Divine Fish, and some have asserted that it is the fish caught by St. Peter, in whose mouth he found a piece of money. This star was an object of worship at the celebrated temple of Demeter at Eleusis, about 500 B.C.

Fomalhaut is a star of apparent magnitude 1.29; its parallax is 0″.14, which tells us that it is about 21 light-years distant from the sun or about five times as far away as our nearest neighbour Alpha Centauri. Fomalhaut emits about 25 times as much energy as the sun.—E. G. Hogg, N.Z. Astronomical Society.

Water Running Up Hill

From "Death Comes for the Archbishop" (Book 5, ch. 2), an admirable historical romance relating to the taking over from Mexico of New Mexico, Arizona, and other portions of the United States, by Willa Cather, one of the best of modern writers:

> Down the middle of the arroyo, through the sunken fields and pastures, flowed a rushing stream which came from the high mountains. Its original source was so high, indeed, that by merely laying an open wooden trough up the opposite side of the arroyo, the Mexicans conveyed the water to the plateau at the top. This sluice was laid in sections that zigzagged up the face of the cliff. Father Vaillant always stopped to watch the water rushing up the side of the precipice like a thing alive; an ever-ascending ladder of clear water gurgling and clouding into silver as it climbed. Only once before, he used to tell the natives, in Italy, had he seen water run up hill like that.

Hypotheses for Summer Consumption

A feature of modern physical science is its abundance of hypotheses. Of course some of these are justified, being based on actual measurements; but others seem simply to spring from the eternal desire of the human mind to speculate. From a recent "Open Letter to Scientists and Friends" I quote a few sentences:

> The theory indicates the earth's crust revolves about an inner sphere, the outer shell repelled by radiation from the inner globe and rays directed inward from the crust. Gravity may be due to several causes, but the chief factor is radiation. The force repels or attracts depending on the power and direction of the predominating rays.
>
> . . . . . .
>
> Weight of objects on earth depends on resistance to rays. Star weight as computed indicates the rate radiation is sent out and absorbed. Planet and stars are not free moving bodies. Whenever rays pass there is force and friction. Matter within the solar system drifts with the sun, subject to the force of rays within and without, and the general laws of motion. Comets when cold move toward the sun due to resistance to incoming rays. When heated they send out radiation actually forcing themselves toward outer space.
>
> . . . . . .
>
> As the theory is incomplete this announcement is to be regarded as preliminary.

C.A.C.

MEETINGS OF THE SOCIETY

AT VANCOUVER

January 8, 1935.—The twenty-eighth regular meeting was held in the University of British Columbia at 8.15 p.m. The president, Professor W. H. Gage, was in the chair.

The president read a series of very interesting accounts of advances made in astronomical science during 1934.

Dr. G. M. Shrum was the speaker of the evening, his subject being, "The Old and the New Radioactive Substances". He preceded his address by telling of the rapid advances made recently in the study and application of the various radioactive substances, and emphasized the importance of the history of science when compared with other histories.

On touching upon the early philosophers, he spoke of Democritus' theory of granular matter of moving atoms, and the continuous matter theory of Aristotle; also of the early philosophers' views of the fundamental substances —fire, air, earth and water, and later mentioned Lavoisier, the discoverer of oxygen 1790, John Dalton, originator of the atomic theory 1805, and Mendeleeff 1870, who tabulated the elements according to their weight or mass. Thus he brought the history of science to the end of the 19th century, and a knowledge of the kinetic theory-atom.

Becquerel came next with the discovery of radioactive rays and its fluorescence, phosphorescence and luminescence. He described Becquerel's experiment with salts of uranium wrapped in dark paper causing a darkening of photographic plate without in the least exciting the uranium. The lecturer also related how M. and Mme. Curie isolated radium from pitchblend whose radiations were detectable, and its third active property, that of ionization.

An interesting explanation of radium radiations followed, with a description of the Alpha, Beta and Gamma rays. The speaker then outlined some of the uses in which these rays are effective, Alpha rays for minor skin diseases, Beta rays for more advanced cases, and Gamma rays for tumors and cancer in their early stages.

An illustration of the bombarding treatment by radium for cancer cure was followed by some important statements. Chemists cannot destroy or change the rate of radiations and disintegration of radium. The kinetic theory took no note of the structure of the atom. The mass of the atom was closely associated with its nucleus. A complex structure of the atom would be unstable. The atomic structure of its nucleus was unknown. The study of the structure of the nucleus is a most important task for science. In further relating the discoveries of science, the speaker mentioned Bothe's expectations of transforming one element to another by bombarding the atoms with the

Alpha rays, these being heavier and better as an atomic projectile. Later Bothe discovered a more penetrating unit in beryllium during the year 1930.

Madam Curie's daughter (Madam Joliot) found that the penetrating unit from beryllium would penetrate two inches of brass and she discovered a third new fundamental particle, known as the neutron. The electron carries a negative charge, the proton a positive charge, while the neutron carries no charge, the proton and neutron having the same mass. In 1932 Anderson discovered a positive electron, but in 1933 expressed doubt as to the positive electron being of any use. The transmutation ot elements was explained as discovered in recent experiments, and in 1934 radioactive elements were made and through these discoveries it would probably be possible in future to inoculate with a radioactive substance that would produce the desired effect in the system and in fifteen hours would lose its radioactivity. In recent years it was discovered that nearly all lighter elements can be made radioactive and many can be transmuted, experiments showing radioactivity or bombardment of radium and pitchblend.

Dr. Shrum concluded his lecture by showing slides, illustrating the proofs of the existence of positive and negative electrons.

February 12, 1935.—The twenty-ninth regular meeting was held at the same time and place, the president being in the chair.

Mr. Paul Sykes gave a very interesting talk on the stars for the month, pointing out the position and magnitude of Nova in Hercules; after which the president introduced the speaker of the evening, F. S. Nowlan, Ph.D., Department of Mathematics, University of British Columbia, whose subject was "The Romance of Numbers".

The speaker described the origin of the number concept to a certain phase in the development of our number system, including the fundamental operations with numbers. He stated that it seems to most people that our number system was always present, or like the decalogue, was handed to the human race in its perfected form. The origin of the number concept is a speculative question that has aroused much discussion but which will probably never be settled. Its genesis in the human race antedates any period of which we have a record. The concept probably antedated intelligent speech and was present when sign language was the only means of communication.

We find a sense of number and a limited ability to count present among lower forms of life—the common crow being able to count to four, but not beyond. Many similar experiments and observations among animals and birds have been made. The lower types of the human race are found to be very efficient in their number sense. Words expressing numbers should be the first to appear in any language, yet the Chiquitos of South America have no numerals at all and other races of Brazil, Australia, Andaman Islands, and elsewhere have no numerals beyond 1 and 2, or 1, 2, and 3, larger numbers beng expressed by heap and many.

Most savage races count to 10 and many cases to 20-100-1000 and in

exceptional cases further. Their ability to count on fingers and toes almost always exceeds the limit set by the spoken language. Our modern system of numeration enables us to express any number although we have no clear understanding of the meaning of large numbers such as a million. At the best our conception of numbers of any magnitude is very hazy. The savage has no conception of an abstraction. He can neither comprehend the word soul nor the number 5. These must be made concrete in their application to be understood.

The origin in English of the numbers 1-10 is unknown, 11 and 12 appear as exceptions and were derived from the Anglo-Saxon words for 10 and 1, 10 and 2 respectively. In general, savage or primitive races count in terms of 10's. In frequent cases the base is 5 or 20 (American Indian) and less frequently a base of 2 (Torres Strait and Australia) and 12 by an African tribe.

The speaker noted that the Babylonians had a number system of which 60 was the base. This system still makes its influence felt in the division of the hour, minute and second, as well as in the angular measure. The necessity of a base for a number system is very urgent as great difficulty would be experienced in counting to a hundred if numerals were words only. The number 10 was chosen as a base because nature impressed it most vividly upon the mind. If 8 or 12 were chosen as a base we should have a different arithmetic. In many respects 12 would be more convenient as it can be more easily subdivided.

The speaker described the invention of mechanical aids in counting, (such as the Abacus), by all races with an aptitude for civilization, in countries as widely separated as Mexico, China, Egypt, and in Europe. These aids are still in use in Russia, China and Japan. He stated that the Abacus lends itself readily to calculations in decimals.

The origin of the Egyptian hieroglyphic symbols for 1, 2, 3, were one finger, two fingers, three fingers spread out, respectively, and later these were straight strokes. In the Roman notation 1, 2, 3, 4 were represented by strokes; later 4 was replaced by IV. The V representing 5 was symbolic of the open hand or five fingers. Those from 5 to 9 were designed on an additive principle, etc., and V inverted surmounted by a V erect forming an X or 10. The symbols L, C, M, 50, 100, 1,000, originated from the Chalcidic alphabet. An interesting explanation followed, with drawings illustrating the evolution of the characters up to the time they were adopted by the Romans, i.e., the well known L, C, D, M. The Greek symbols were the Herodianic signs or Attic notation which in the Third Century B.C., were replaced by the Alexandrian system in which numbers 1 to 9 were represented by letters Alpha to Theta. The notation we employ to-day being of Arabic origin, its invention and development may be considered as one of the greatest triumphs of human genius, for it alone made possible the marvellous powers of modern calculation which underlie all progress in Science and Industry. The significant

feature of this notation (due to the Hindoos) is the symbol for zero which had never previously been represented, and the principle of position whereby the value of a digit is determined by its position in the number symbol: thus, a digit 2 represents units, tens, hundreds, etc., according to whether it occupies the first, second or third place in the number counting from the right. Cajori, in his History of Mathematics, states: "The grandest achievement of the Hindoos, and the one which, of all mathematical investigations, has contributed most to the general progress of intelligence is the invention of the principle of position in writing numbers." This principle as well as the symbol for zero was a new idea. These two principles enable us to represent any number by the use of only ten distinct symbols. The zero was not introduced into Indian notation until 500 A.D. and the principle of position and the zero were introduced into Arabia about 770 A.D.

Considerable hostility was shown to their introduction to Europe. Their spread and adoption were in large part due to the makers of calendars and almanacs. The earliest known use of the Arabic notation in Britain was 1400. Leibnitz, the famous German mathematician, who shares with Newton the honour of inventing the calculus, devised a system in which the number 2 served as a base; in this binary system only two numbers were required to express any number. Leibnitz declared this system symbolized the creation, God being represented by unity and nothing by zero, signifying God made all from nothing. The abacus method of computation was known as "iron division", and the simplified Arabic method as "golden division".

An interesting description of Napier's Rods (invented by Napier who invented logarithms) was given and their uses in multiplication and in extracting square and cube roots were demonstrated. The common *plus* and *minus* signs were first used in Widman's *Arithmetic*, published in 1489. It took over a century to establish their use. The X sign for multiplication was introduced in 1631 by Oughtred. The symbol was first used by John Rehn at Zurich in 1659. The symbol for equality = was introduced in 1556 by Record, an Englishman, who claimed that "no two things can be more equal than two parallel lines".

Later on the slide rule replaced Napier's Rods and adding machines replaced the abacus.

The speaker extended his very interesting and instructive talk by describing some new mechanical and electrical machines, developed by the Massachusetts' Institute of Technology. One machine, the differential analyzer, is used for the solution of differential equations of any order up to the sixth. Another even more amazing invention, the factoring machine, on exhibition at the Century of Progress Fair at Chicago, is capable of performing in from two to three hours calculations that would require 300 years to perform in the ordinary way.

March 12, 1935.—The thirtieth regular meeting was held at the usual time and place, the president being in the chair.

Professor Gage introduced to the meeting the speaker of the evening, Dr. C. S. Beals of the Dominion Astrophysical Observatory at Victoria, B.C. Dr. Beals' subject was "What is a Star?".

The speaker stated that early interest in the stars was in general confined to their motions. The study of stellar structure owes its advance to men such as Lane, Kelvin, Helmholtz, Ritter, Jeans, Eddington, Milne and a host of others. As a result of their researches we have what we might consider a working model of a star or of a family of related stars. After showing several slides to illustrate the large number of stars, the speaker considered the definition of a star. Dr. Beals asked his audience to consider a mass of gas about one thousand billion miles in diameter, of low temperature, invisible, and subject to no external forces. Gravitation would tend to compress the gas toward the centre of mass, slowly at first but generally steady. The heat generated by compression would eventually tend to slow up the contraction process and at some stage pressure radiation would more than balance contraction.

The speaker then showed slides of our sun, an average common star, to illustrate the probable picture of a star at close quarters. He discussed the distribution of density of a star and pointed out that the central density for some stars is as much as 40,000 times that of water. He also commented upon the temperatures of stars. The surface temperatures of the sun is about 6,000° absolute, that of the coolest known star is about 2,000°, and that of the hottest star is about 10,000°. The central temperatures, however, in some cases have been estimated to be about 40,000,000°. The gases exist with these high temperatures and densities only because the atoms have been broken up.

The smallest star, stated the speaker, has a diameter of 6,000 miles but has a mass about 100,000 times the mass of the earth. The largest star has a radius of 400,000,000 miles. The masses of the smallest and largest known stars are 100 times and 0.14 times the mass of the sun.

Finally the lecturer considered the theories of the source of stellar energy. Although contraction might have been the original source, undoubtedly it could not be sufficient to account for the life of a star as required by geological considerations. At present scientists regard the Einstein theory, which supposes mass to be transformed into energy, as a possible explanation.

C. A. McDonald, *Secretary.*

AT VICTORIA

May 1, 1935.—Com. Tingley occupied the chair, notifying the Society that the President, Mr. H. Boyd Brydon, owing to illness, would be unable to take active part for some time.

Mr. Hobday announced that permanent quarters for the Telescope Making Section had been secured. Mr. Robert Peters gave his fifth descriptive talk on the constellations and planets. He dealt on this occasion with Hercules, locating the famous cluster and describing Alpha Hercules as a great star some 340 million miles in diameter.

Dr. J. A. Pearce was then called upon for his address on "Our Galaxy, a typical Spiral Nebulae". He said he would attempt to answer the question, Do we live on the inside of a spiral nebulae? Sir William Herschel was the first to determine that we belonged to a definite system of stars which had a certain lenticular form. The lecturer described how Herschel with his sister's help swept the heavens night after night with his 20-inch reflector, counting the stars. He was followed by a Dutch astronomer Easton, who, though little known, was the first to suggest that our galaxy was a spiral and that we lived on the inside of it. Much later, in 1918, Kapteyn, also a Dutch astronomer, proposed the spiral as a likely form, his deduction coming from the distribution of variables. Shapley, by a study of globular clusters, suggested a diameter of 10 times the thickness, giving a total diameter of 250,000 light-years. This would seem to be about five times the size of the Andromeda nebula. However, by their determination of the rotation of our galaxy, Drs. Plaskett and Pearce reduced the size to around 100,000 light-years. On the other hand Stebbins and Hubble by photometric methods found the size of the Andromeda to have been underestimated. Thus our galaxy has been brought in line with typical spirals in size. Numerous photographs showed the typical spiral to be lenticular in shape. It was further shown that they contain similar numbers of Novae, Cepheid variables and diffuse nebulae, and are surrounded by globular clusters; hence ample evidence of our galaxy's being similar to other stellar systems was conclusively proven. In answer to questions, Dr. Pearce stated that the nearest island universe was about 85,000 light-years, while the farthest measurable was 840,000,000 light-years.

GORDON SHAW, *Secretary.*

AT TORONTO

April 2, 1935.—A special meeting of the Toronto Centre, being a joint meeting with the department of astronomy of the University of Toronto, was held in the lecture theatre of the McLennan Laboratory of the University; A. R. Hassard in the chair.

The meeting was arranged by Dr. C. A. Chant to make an inspection of a six-reel motion picture film, "Looking Through Great Telescopes", which had been loaned for private view by the Araneff Film Associates of Chicago. Dr. Chant spoke briefly about the film, and thanked Mr. R. B. Shaw, secretary of the Dominion Educational Film Association, for his kindness in securing the film for inspection by the university and the society.

The film, which was produced at the Dearborn Observatory of Northwestern University, Evanston, Ill., was mainly comprised of photographs from the larger United States observatories including Mount Wilson, Yerkes, Lick and Harvard.

The first reel dealt with solar phenomena, the chromosphere and prominences, changes in sunspot groups, and included an excellent view of a total eclipse. The second reel portrayed the lunar landscape with its craters and

vast plains. The third illustrated the phases of Venus, the seasonal changes of Mars and the appearance of the planet with infra-red photography, asteroids and comets, and concluded with a "shot" of shooting-stars. Reel four, made up mainly of Lowell Observatory photographs, illustrated the appearance of the outer planets and the discovery of Pluto. "The Milky Way, Pathway of the Gods", was the title of the fifth reel which included double stars, globular clusters, gaseous nebulae and the Magellanic clouds. Reel six concluded the film and showed the extra-galactic or spiral nebulae.

April 9, 1935.—A regular meeting was held at the usual time and place; A. R. Hassard in the chair.

Two candidates were elected as members-at-large:

Mr. Jonas A. Barish, 41 Ellwood Ave., Mt. Vernon, N.Y.

Mr. J. Fullerton Gressitt, Misakicho, Kanda, Tokyo, Japan.

Astronomical phenomena for the month was outlined by F. L. Harvey. J. R. Collins pointed out that on April 12, the planet Mars would be at its closest approach to the earth during 1935, and also showed a lantern slide taken recently at Lick Observatory, illustrating a "white cloud" observed on the planet. F. L. Troyer reported upon recent astronomical events.

S. C. Brown, secretary of the Toronto section, spoke on "Telescope making for amateurs". He especially mentioned the evident falling-off in the number of useful observations reported at the meetings during recent years, which, the older members who had possessed telescopes and made good use of them. As a remedy for this lack of interest in telescopic observation, he suggested the formation within the society of an amateur telescope making club or section. Mr. Brown emphasized that the amateur telescope maker can, with some experience, make an instrument which will be equal in performance to those manufactured by commercial firms. He suggested that the beginner should start with a six-inch mirror so as to gain experience in overcoming the inevitable troubles of figuring a parabolic curve. After completing a six-inch mirror, the amateur may become more ambitious and make progressively larger sizes. Mr. Brown described and demonstrated the various processes in mirror-making, from the rough glass disc to the completed reflector and particularly referred to the methods by which various departures from the parabolic curve can be recognized and controlled.

FREDERIC L. TROYER, *Recorder.*

April 30, 1935.—A regular meeting was held at 8.00 p.m. in the McLennan laboratory, University of Toronto; Mr. A. R. Hassard, K.C., in the chair.

Miss Elnora Parkin, 7 Rosehill Avenue, Toronto, was duly elected to membership in the Toronto section.

Dr. Helen S. Hogg then addressed the members on Mars. With the exception of the moon, Mars is the one celestial body particularly suited for close-up observation. The first recorded mention of Mars was made in 272 B.C. and passed down to us in Ptolemy's records. For many years the study

of the Martian surface has been carried on very intensively, especially when the planet is in opposition, as it is at the present time. The distance of the planet from the earth varies greatly at successive oppositions because of the eccentricity of the planet's orbit, and the most favourable opposition occurs when Mars is closest to the sun or in perihelion. Thus when the opposition occurs in August it is best suited for observation. The magnitude of the planet varies over a wide range, from minus 2.8 when in opposition to plus 1 when it is in conjunction or on the opposite side of the sun. The inclination of the Martian axis to the plane of its orbit is within a degree of that of the earth's.

Dr. Hogg exhibited slide reproductions of drawings of the Martian surface as seen by various astronomers over a period of more than two hundred years. The surface feature which has been most emphasized is the so-called "canal system". Perhaps the most noticeable surface features, however, are the polar-caps and their seasonal changes. As the snow melts, many observers notice a deep blue belt around the polar-cap which is usually considered to be water, although a few astronomers have suggested that the caps may be solidified carbon dioxide. Dr. H. N. Russell has stated that, if the polar caps are snow, the total amount of water on the planet would probably be insufficient to fill Lake Erie.

Another feature is the reddish colour in certain areas, presumably deserts. Although smaller than the earth, the proportion of these deserts on Mars is much greater. This is of course to be expected, as Mars, being of smaller mass, would go through its life-cycle more rapidly than a larger planet. There are other areas which appear bluish-green at some times, but in which changes of colour have been reported by many observers, including Antoniadi and Lowell. These changes may be due to chemical action, and do not necessarily imply vegetable life. White areas are sometimes observed apart from the polar caps. This phenomenon might be connected with mountains, but Lowell has calculated that there are no mountains or plateaus higher than 2000 or 3000 feet.

One of the strongest and most long-lived arguments among astronomers, and the one that holds a peculiar appeal to the popular mind, is the question of "canals" or straight markings on Mars. The size of the direct image of Mars as produced by the largest refracting telescope in the world, that of Yerkes Observatory, is only one-tenth of an inch. In photography the astronomer experiences great difficulty in steady "seeing", and usually the finer details are blurred out, thus the canals of Mars have never appeared on a photograph, but this alone does not prove that they do not exist. The visual observer, looking for these canals, sometimes gets very short periods, usually for only a fraction of a second, of good seeing, and many drawings have been made which include these canals. On the other hand, Dr. Hogg explained, there is a possibility that such markings are only the result of an optical illusion, in which the observer imagines straight lines connecting the dark spots which are known to exist.

For many years it has been definitely known that Mars has an atmosphere

of some kind. The appearance and disappearance of the planet's polar caps necessitates a medium for the transportation of the water vapour or other substance of which the caps are composed. Occasional clouds, especially the white markings sometimes seen at the terminator, whether they are dust clouds blown up from the desert or clouds of water vapour, certainly provide additional evidence of an atmosphere. This atmosphere must be very rarefied as the telescope gives little evidence of its existence, and the planet's mass is too small to hold gases such as free hydrogen. Mars, like the earth and the other planets, has probably lost most of its original atmosphere. Recent tests made by Adams at the Mount Wilson Observatory show that Mars has less than one-thousandth the free oxygen which exists in our own atmosphere.

Radiometric measures of the surface temperature show that at the Martian noon the temperature increases above 10 degrees Cent., although the night temperature is far below zero. Clouds are rather rare. Mars has thus what might be called "perfect" weather. The inclination of its axis makes the seasons much like our own, except in that they are longer. Dealing with the question as to whether Mars is fit for habitation, Dr. Hogg stated that there is at present no proof either for or against the existence of life, although there seems to be nothing which would make life in one form or another an impossibility. There are, at best, only two planets in the solar system, besides the earth, which contain necessary essentials for life; they are Mars and Venus.

The satellites of Mars provide some very interesting phenomena, especially to an observer who might be situated on the planet itself. Predicted by chance by Jonathan Swift in his "Gulliver's Travels" in 1726, they were discovered in 1877, a century and a half later, by Asaph Hall. A remarkable coincidence was that in the case of both satellites, Phobos and Deimos, Swift had, in his novel, stated their distances from Mars and their periods of revolution almost exactly. If a Martian observer lived within 7½° of either pole the curvature of the planet would prevent his seeing Deimos, which is only 12,500 miles distant from the surface of the planet. If within 21° of either pole, he would, for the same reason, be unable to view Phobos, which is less than 3750 miles distant from the surface of the planet. Both satellites keep the same face towards Mars, and Phobos is the only satellite in the solar system which revolves around the planet in less than the rotational period of the planet itself. With a sidereal period of only 7½ hours it thus appears to rise in the west and set in the east. It might be described as a "little planetarium" for while it is above the horizon, during a period of less than four hours, it goes through approximately half its phases. From the satellite Phobos, Mars would fill a large part of the sky, subtending an angle of more than 42°. Mars would be a "happy hunting ground" for the astronomer who is an inveterate eclipse follower, for there occur several eclipses per day.

Dr. Frank S. Hogg, S. C. Brown, J. R. Collins, A. R. Hassard and Dr. Helen S. Hogg outlined the work of the various observation sections as proposed for the summer months. FREDERIC L. TROYER, *Recorder.*

AT MONTREAL

November 2, 1934.—The first meeting for the 1934-35 season was held in the Macdonald Physics Laboratory at 8.30 p.m., the president, Mr. G. Harper Hall in the chair.

New members were elected as follows: Dr. Malcolm A. Hickey, Dr. W. W. Eakin, Mr. J. Addison Reid, Mr. A. C. Berman, Mr. R. A. Hunt.

The secretary referred to the losses sustained by the society in the death of Mr. Justice E. E. Howard, one of the original members of the Centre, a past-president and member of Council; and of Dr. D. A. Murray, vice-president. It was moved and carried that the sympathy of the society be conveyed to the families.

The lecturer was Mr. Erland Echlin, secretary of the Rational Calendar Association of Canada and his subject was Calendar Reform.

The historical aspects of the calendar problem were dealt with, the inadequacies of the present calendar, the efforts of the League of Nations and the present attitude towards reform of the calendar in various countries. A good discussion followed upon the relative merits of 12 and 13 month calendars, the attitude of various religious bodies and so forth.

December 4, 1934.—The meeting was held in the Macdonald Physics Laboratory at 8.30 p.m. This was an extension lecture under the auspices of the Department of Extra Mural Relations of McGill University, with whom financial arrangements were made that members of the R.A.S.C. might attend.

Lecturer: Dr. A. Vibert Douglas; subject: The Outer World.

The speaker showed how dependent the astronomer is upon the knowledge gained in various branches of physics, Light, Heat, Electricity, Magnetism, Waves, The Atomic World, (the topics of the previous lectures of this extension series); and likewise how astronomical and astrophysical knowledge had reacted upon physics and enriched natural philosophy.

The Michelson interferometer was shown in actual use and other demonstrations included the spectroscope, emission lines and the production of the sodium absorption line.

Questions were answered and everyone present had an opportunity of counting the fringes due to Hg λ 5461 in the interferometer.

January 18, 1935.—The meeting was held in the Macdonald Physics Laboratory at 8.30 p.m. The president, Mr. George R. Lighthall, was in the chair.

New members elected were: C. K. Calhoun, P. L. Neilson, A. V. Stroud, T. G. Turnbull.

The speaker of the evening was Dr. C. A. Chant, professor of astronomy at the University of Toronto. The subject, the David Dunlap Observatory, was of very great interest to the members of the society. The new telescope is at present the second largest in existence, and it will be a powerful means to advance astronomical research in Canada.

February 28, 1935.—The meeting was held in the Macdonald Physics Building. The president, Mr. George R. Lighthall, occupied the chair.

The speaker for the evening, Professor A. H. S. Gillson, gave an extremely interesting talk on Conic Sections and Astronomy.

The growth of geometry was traced from the time of Thales up to the present concept of space-time as formulated by Einstein. The geometry of the conic sections was started by Menaechmus, a pupil of Plato. By the use of the conic sections, the Delian problem was first solved. The names of the conic sections were given by Appolonius. It was not until the time of Kepler that the geometry of conic sections was applied to astronomy. Kepler discovered that the orbits of the planets were ellipses. The investigation was carried further by Newton. The hyperbola has now come into an important place with the relativity theory of Einstein.

March 26, 1935.—The meeting was held in the Macdonald Physics Laboratory; the president, Mr. George R. Lighthall, in the chair.

The lecturer was Dr. S. A. Mitchell, Director of the Leander McCormick Observatory, Virginia. Subject: A Journey to the South Seas to observe a Total Eclipse.

By means of slides the lecturer showed the preparations for observation of a total eclipse at Tin Can Island, Tonga Group, South Pacific. He discussed the corona, the chromosphere and flash spectrum, the relative heights to which different elements rise, the evidence for ascending and descending currents and the correlations between spectrum lines of low and high excitation potential with doppler displacements, and the residual Einstein displacement.

The vote of thanks was proposed by Alderman D. P. Gillmor, K.C., and carried with enthusiasm.

April 25, 1935.—The meeting was held in the Macdonald Physics Laboratory at 8.30 p.m. The president was in the chair.

New members were elected as follows: Mrs. M. Goodman, Mr. H. Warren K. Hale, Mrs. W. H. Warner.

Three addresses were given to a capacity audience as follows:

(1) Mr. E. Russell Paterson—Meteors.
Special reference was made to the organized observations by Boy Scouts last summer and autumn.

(2) Mr. F. De Kinder—Summer Observations.
An account of the evenings with the R.A.S.C. telescope on the balcony of the Sun Life Building.

(3) Mr. G. Harper Hall—Photography in Relation to Astronomy.

Questions and discussions followed the addresses. The secretary then told of the formation of an R.A.S.C. (Montreal Centre) Library, the nucleus of which was displayed and the names of the donors announced, 21 volumes to

date. The honorary librarian is Mr. F. De Kinder. The president invited visitors to become members of the Society.

May 2, 1935.—The seventh and final meeting for the season 1934-35 was held in the Macdonald Physics Laboratory. The president was in the chair.

New members were elected as follows: Mr. Alfred Donnelly, Mr. Harold S. Weldon, Mr. F. P. Jennings.

Six reels of moving picture 16 mm. film of the Araneff Co., Chicago, were shown entitled "Through Great Telescopes—(1) The Moon, (2) The Sun, (3) Inner Planets and Comets, (4) Outer Planets, (5) The Milky Way, (6) Spirals.

Members expressed their enjoyment of the film and appreciation of the skilful manner in which Mr. S. Amesse ran them through.

The members of the Committee did not feel that the films justified so great an expenditure as $45.00 per reel, so the Secretary was instructed to write the makers that unfortunately no purchase could be made.

A. VIBERT DOUGLAS, *Secretary.*

AT OTTAWA

March 8, 1935.—The Ottawa Centre opened a series of popular lectures on this date. The president, Mr. A. H. Miller, stated that the course would be elementary, beginning with the history and development of the universe, then proceeding to the marvels of our galaxy, then to the sun and planets of our system, and finally to the method and use of meteor observing. He then called on Mr. R. Meldrum Stewart, the director of the Dominion Observatory, to speak on a subject which has engaged the minds of great thinkers through the ages, namely, Cosmogony and Cosmology.

An abstract of Mr. Stewart's address follows:

The ancients thought that the earth was the centre of the universe, and generally that their own city or country, whatever it might be, was the centre of the earth. Their ideas of the origin of things were naturally vague, and usually bound up with mythology and systems of gods and goddesses and mythological heroes. These geocentric ideas, though gradually improving in form, persisted in a general way up to the time of Copernicus.

One of the next questions to arise was the source of light and heat. In the nineteenth century this source was considered to be the gradual shrinkage of the sun due to its own gravitational attraction. This would have been sufficient to account for a past life of about fifty million years. The unearthing of evidence that the earth in its present condition is at least a thousand million years old necessitated radical changes in this hypothesis. The sun's light and heat are now supposed to be due to the release of sub-atomic energy in some form.

Another main problem was the method of formation of the solar system. During the last century Laplace's nebular hypothesis held sway, according to

which the formation of the various planets was due to the casting off of successive rings in a contracting nebula which originally filled the whole space occupied by the solar system. This hypothesis has now been abandoned, and the solar system is thought to have originated from the tearing out of portions of the sun's material through the mechanism of enormous tides raised by the close approach of a passing star in remote ages.

The greatest problem of all is the structure of the stellar universe, far beyond the solar system, of which the spiral nebulae are considered to hold the key. Millions of these are known to exist, and are scattered through space as far as our telescopes can penetrate. How much farther they extend we do not know. Our own spiral nebula is known to us as the Milky Way or Galaxy, and contains thousands of millions of suns similar to our own.

At the close of the address, Mr. Miller opened the meeting to discussion, and because of their general interest some of the questions have been recorded, with answers by Mr. Stewart.

Q. If we hold to the theory of the near passing of a star causing our planetary system, why is it that not all the members of that system rotate in the same direction? For instance, one of the satellites of Jupiter rotates in reverse direction.

A. The particular theory after all serves only to correlate observed facts, and the best theory is that which serves truthfully the greatest number of observed facts. A discrepancy such as one of the satellites revolving in reverse direction may be the result of a body foreign to our planet system coming in from outer space and being attracted to a planet in such a way that its motion would be the reverse of satellites native to our system.

Q. If the near passing star disrupted our original sun sufficiently to tear out a mass which resulted in our planetary system, would our sun do the same to the other star?

A. Not necessarily, and probably not. Both stars would be violently disturbed, but the smaller of the two would suffer the greater disturbance. It is thought possible that in our case the other star might have been the more massive by many times so that our effect on it would be very small.

Q. Are the dark clouds or nebulae in the Milky Way retaining their shape or are they changing?

A. They are likely changing and very rapidly but they are so far away that we would not notice the changes for thousands of years.

Q. If our sun is a star, are the stars like our sun?

A. Yes, to a certain extent. The chances of an individual star approaching near enough to another that planetary systems such as ours would be developed is very remote. Though many planetary systems may exist, it is certain that most are not accompanied by such systems.

Q. Is it possible that we actually see the stars by the light of our own sun being reflected back?

A. The light reaching us from each star is characteristic of its physical con-

dition—temperature, degree of ionization, density, etc. Reflected light originating in the sun would still be sunlight and could be identified as such. There are some of the nebulae, however, which we see as illuminated by stars associated with them. In this case the illumination is probably not true reflection, but excitation by light of extremely short wave-length, re-radiated at a longer wave-length.

Q. How does our galaxy compare in size with others?

A. Until recently it was considered that our system was much the greatest in size and importance. But in the light of more recent observation it would seem rather that our galaxy is of somewhat the same order of size as many thousands of others which occupy space.

Q. Could you give us some idea of the theory of the Expanding Universe?

A. Spectroscopic observations of the spiral nebulae, which are the most distant objects visible to us, exhibit a displacement of the spectrum lines toward the red, the displacement being roughly proportional to the distance. Under ordinary circumstances this would indicate a velocity of recession, and we know of no definite reason why it should not be so interpreted in this case also. If this explanation is accepted it follows that the universe is expanding, the velocity of expansion being proportional to the distance. On the other hand, if we assume that the individual bundles of light (photons) are continually losing energy in their passage through space, the same displacement of the spectrum lines toward the red would occur, without any actual motion of recession. The whole question is still unsettled.

March 15, 1935.—The second lecture of the series was given in the Victoria Memorial Museum by Professor A. H. S. Gillson of McGill University. His subject was, "The Stellar Universe: a discussion of the nature, magnitudes, colours, distances and masses of the stars and how these quantities are measured." The president, Mr. A. H. Miller, was in the chair. Though the subject was a very broad one, it was ably covered by the speaker. By means of diagrams and slides Professor Gillson was able to make many otherwise difficult points clear to his audience. A brief summary of his lecture follows:

Starting from a discussion of the number of stars visible to the naked eye in the whole sky, the speaker went on to tell of their division into constellations, and later into various magnitude groups. The first star catalogue was made by Hipparchus about 125 B.C. and this gave the positions of the stars. He considered the 20 brightest stars as of the 1st magnitude and those just at the limit of visibility to the naked eye as of the 6th. Stars of each class are 2.5 times fainter than those of the preceding class. At the present time an instrument called a photometer is used to measure stellar magnitudes either visually or photographically. Owing to the difference in colour sensitivity between the eye and the photographic plate, there is a difference between visual and photographic magnitude. This is called the colour index, since it is also an indication of the star's colour.

From photographic plates the number of stars in "our universe", or

galaxy, may now be placed at 30,000,000,000 and yet their combined light gives only 1/15,000,000 that of our sun.

Mention was made of the study of Cepheid variables by Miss Leavitt at Harvard. By means of a law known as the Leavitt-Shapley law, connecting the periods and absolute magnitudes of these stars, their distances may be computed. It is in this way that distances of the globular clusters and spiral nebulae have been estimated. In the case of the Andromeda nebula the distance turns out to be 900,000 light-years.

The method of finding distances of the nearer stars by parallax was explained. At present about 2000 stellar distances have been determined by this method. Slides demonstrated the interferometer, an instrument used for measuring stellar diameters.

Masses of double stars may be computed from observation data and it has been found that the masses of most stars are within the limits of one-half to five times that of the sun. In this connection the lecturer spoke highly of the work of Dr. J. S. Plaskett, of the Dominion Astrophysical Observatory.

The two types of motion of which stars partake were carefully explained, namely, proper motion or motion across the line of vision, and radial velocity, or motion along the line of vision. For the detection of the latter we are indebted to Newton who first studied the spectrum produced by a prism, to Wollaston, who studied the lines and their positions in the spectrum, and to Doppler for the connection between radial velocity and line shift in the spectrum.

In speaking of the rotation of the galaxy, mention was again made of the outstanding work of Dr. Plaskett. It is now known that the whole galaxy is in rotation, in a similar manner to the motion of the spiral nebulae. Calculation shows that the galaxy takes 280,000,000 years to complete a rotation and that our sun is so far from the axis of rotation that it is moving at the rate of 200 miles per second.

The classification of stars according to their spectra and also their process of evolution were touched upon.

In conclusion Professor Gillson referred to the views held by Russell, Eddington and Einstein regarding stellar evolution. According to Einstein, our sun is losing mass at the rate of 4,000,000 tons per second. It is now a "G" dwarf, and as its mass decreases, the earth will recede from it, getting less and less heat, and our day will become longer and longer.

March 22, 1935.—The third of the series of popular lectures was held in the Victoria Memorial Museum. The title of the lecture was "The Solar System,—interesting astronomical phenomena in everyday life and what is known regarding our nearest neighbours, the planets", by Dr. R. J. McDiarmid of the Dominion Observatory. The president of the centre, Mr. A. H. Miller, was in the chair. A short account of Dr. McDiarmid's lecture follows:

Since the motions of members of the solar system have been understood for years, the speaker confined his attention chiefly to the physical character-

istics of the planets. These characteristics are controlled by three conditions: (1) Distance from the sun, which determines the amount of heat. (2) The length of the planet's day. (3) The mass of the planet.

The lecturer pointed out that before studying conditions on the other planets, matters would be greatly simplified if we made a more or less extensive study of conditions on and surrounding the earth. With this in view, Dr. McDiarmid took his audience on a rocket trip through the earth's atmosphere, studying the various phenomena encountered, etc. Following this a short description was given of the physical conditions of the moon, Mercury, Venus, Mars, the Asteroids, Jupiter, Saturn, Uranus, Neptune and Pluto.

Speaking of the earth's atmosphere, such phenomena as the changed appearance in colour and size of the sun when setting were explained as caused by our atmosphere; similarly the existence of twilight. Various things were enumerated which would occur were it not for our protecting blanket of atmosphere.

There are three ways of studying the earth's atmosphere, (1) by light waves that come to us from outside the earth, (2) by radio waves generated on the earth, (3) by sound produced on the earth. In other words, said the speaker, "the knowledge of everything outside the earth comes to us in the form of radiation and especially as light".

Different types of radiation were mentioned, in all there are 64 octaves of ether radiation, ranging from the infra red to the cosmic rays. In the sound waves, our ears detect eleven octaves, but our eyes detect only one octave of light.

All light which enters our atmosphere is scattered, and owing to the fact that the blue is scattered more than the red, our sky appears blue. It is for the same reason that infra red (the less scattered light) is so valuable in aerial photography.

The composition of our atmosphere was discussed and also the results of various balloon flights. For instance, the drop in temperature as one goes away from the earth, the increase of cosmic radiation with altitude, the almost black appearance of the sky, and the stars standing out clearly in daylight.

At a distance of about 75 miles the earth meteors first appear. It has been estimated that a million meteors enter our atmosphere hourly; again it is our atmosphere which protects us from this bombardment. Slides showed the effects of some of the larger meteorites which have struck the earth, and one could imagine the terrific destruction that would have resulted had these fallen in populated regions. Examination of these meteorites shows they are probably fragments of larger bodies from interstellar space.

As one recedes from the earth's surface, the atmosphere becomes more and more tenuous, though by means of the aurora traces of it are still found at 400-500 miles from the earth. Were one to go beyond that, the sky would be black, stars would not twinkle and no sounds could be heard.

Considering now the moon, one finds on it no atmosphere, so there is no

twilight but at sunset intense darkness comes at once. A description of the moon's surface was given, also its characteristics and the conditions prevailing there. A million meteorites are calculated to fall on the moon's surface daily.

Only brief mention was made of the sun, since a later lecture will deal with that subject more fully. In turn conditions on each of the planets were reviewed, and a few of these remarks are given below.

Mercury: no atmosphere; low reflecting power; temperature on its surface directly under the sun, 675°F.

Venus: by calculation its temperature should be 80°F. higher than the earth; completely encased in clouds too thick to see through; atmosphere largely carbon dioxide.

Mars: slight atmosphere detected by its larger size in ultra-violet photographs than in infra-red ones; on equator at midday, temperature is 60°F., but drops at night to below zero.

Asteroids: largest 480 miles in diameter; probably once a planet between Mars and Jupiter which was caused to break up into thousands of parts; no atmosphere on these bodies.

Jupiter: covered with clouds which show remarkable changes; temperature 180°F. below zero; clouds composed mostly of ammonia and methane.

Saturn: temperature 220°F. below zero; atmosphere mostly methane; markings and clouds behave in a similar manner to those of Jupiter.

Uranus, Neptune and Pluto show evidence of atmosphere of methane, and are colder and more desolate.

Dr. McDiarmid pointed out that from this survey we see that the larger planets have atmospheres mostly of hydrocarbons, (ammonia and methane); medium sized ones have atmospheres of compounds of oxygen, while the small planets, asteroids and satellites have no atmosphere.

March 29, 1935.—The fourth of the series was held at the Victoria Memorial Museum. Dr. Ralph E. DeLury, Assistant Director of the Dominion Observatory, was the lecturer. His subject was, "The Sun—What the astronomer knows about the sun and its relation to phenomena on the earth". The chair was occupied by the president, Mr. A. H. Miller.

With the aid of slides, the lecturer gave an excellent description of the solar atmosphere, the pores which cover its surface, sun-spots, high-level clouds, prominences and coronal forms seen at times of solar eclipses. The method of taking photographs by means of the spectroheliograph—that is in one particular wave-length—was described and illustrated. The solar spectrum was discussed and methods of determining the rotation period outlined. Particular attention was given to the nature of the sun-spots, the emission of ultra-violet light and its changes, with resultant changes on the earth in electromagnetic disturbances. The eleven-year cycle of sun-spots was described and many slides illustrated the relationship between them and terrestrial

phenomena, such as rainfall, tree growth, number of insects, birds, animals and agricultural products which in turn have a great effect on economic conditions.

April 5, 1935.—This was the last of the series of popular lectures at the Victoria Museum. The speaker was Dr. Peter M. Millman, of the department of Astronomy, University of Toronto. His subject was, "The How and Why of Meteor Observing". A summary of Dr. Millman's lecture follows:

The birth of meteoric astronomy might be dated as the morning of Nov. 13, 1833. From midnight to dawn on that date the sky was filled with meteors and the phenomenon of radiation from a certain point among the stars was then first definitely recorded. This fact clearly indicated that meteors were of cosmic significance and it was not long till the November meteors were shown to be moving in an orbit about the sun similar to that of a comet. In fact, several showers of meteors were found to be moving in orbits identical with those of certain well-known comets. Through simultaneous observations from two ends of a base line it has been found that meteors appear at an average height of 60 miles above the surface of the earth. One of the most striking of recent discoveries is that many meteors show surprisingly high velocities, a fact which indicates that a large percentage of those not connected with well-known showers come from the depths of space far outside the solar system.

Photography of meteors, both direct and spectroscopic, naturally presents some difficulties but many meteor photographs have been secured by chance on astronomical plates, and rerently programmes conducted for the purpose of meteor photography have met with considerable success. The long-enduring trains of bright meteors are of particular interest and through their study we may discover much concerning the nature and movements of the upper atmosphere.

When a meteor is large enough to resist complete vaporization in the earth's atmosphere it falls to the ground as a meteorite and the study in the laboratory of this debris of space is a subject of great importance. A determination of the helium content of 24 meteorites has recently shown that in all the cases studied they have existed in their present condition for less than 3000 million years. This is the upper limit of age usually assigned to the earth's crust. It is remarkable that even meteorites from outside the solar system show no indications of a greater age. Another important development of the last few years is a recognition of certain geological features of the earth's surface as the results of the impact of giant meteorites. At the present time there are eight localities on the earth where authentic meteor craters are known to exist.

The problem then is: "What can the amateur do to assist in the study of meteors and meteorites?" Briefly, the most important thing is to have as complete information as possible about as many meteors as possible. To this end everyone should report intelligently and immediately to some observatory

the appearance of any bright meteor. Twelve points should be remembered in making the report. They may be classified thus:

I. *The observer*—name, place, time.

II. *Position of meteor*—azimuth, altitude, slope.

III. *Appearance of meteor*—brightness, colour, speed.

IV. *After effects*—train duration, train motion, sounds.

In addition to reporting meteors seen by chance definite help can be rendered by observing for stated periods and plotting the meteors on star maps. This type of observation is particularly valuable when there are several co-operating stations. The last half of July and the first half of August is a period when meteors are particularly numerous. In the summer of 1934 over 6000 observations were made in Canada, mostly in Ontario. It is hoped that this number will be doubled this year. Full instructions and maps for this type of work may be obtained from P. M. Millman, at the Department of Astronomy, University of Toronto.

For those interested in photography the study of meteors is the one field where the amateur photographer can do work on a par with the professional astronomer. This is chiefly because the best type of camera for meteor photography is a small one with a 5- or 6-inch focal length and a lens of speed F/4.5, and because an expensive equatorial mounting is not required. The camera is kept stationary during the exposure. Many excellent photographs of meteors have been taken by amateurs. The most important requisites for success in this work are enthusiasm and a persistence which is not overcome by initial failures. These, plus an intelligent application of photographic technique, should make it possible for any amateur photographer to add valuable data to the all-too-scanty supply which at present exists.

Slides were used through the lecture, and an ingenious device projected a meteor shower on the screen. At the close of his talk, Dr. Millman very kindly answered many questions.

MIRIAM S. BURLAND, *Acting Secretary.*

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